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[54] **ELECTROLIC CONTROL VALVE**

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[51] **Int. Cl.** **F15b 21/08**

[58] **Field of Search** 60/471, 484, 420, 464, DIG. 2; 91/414, 459

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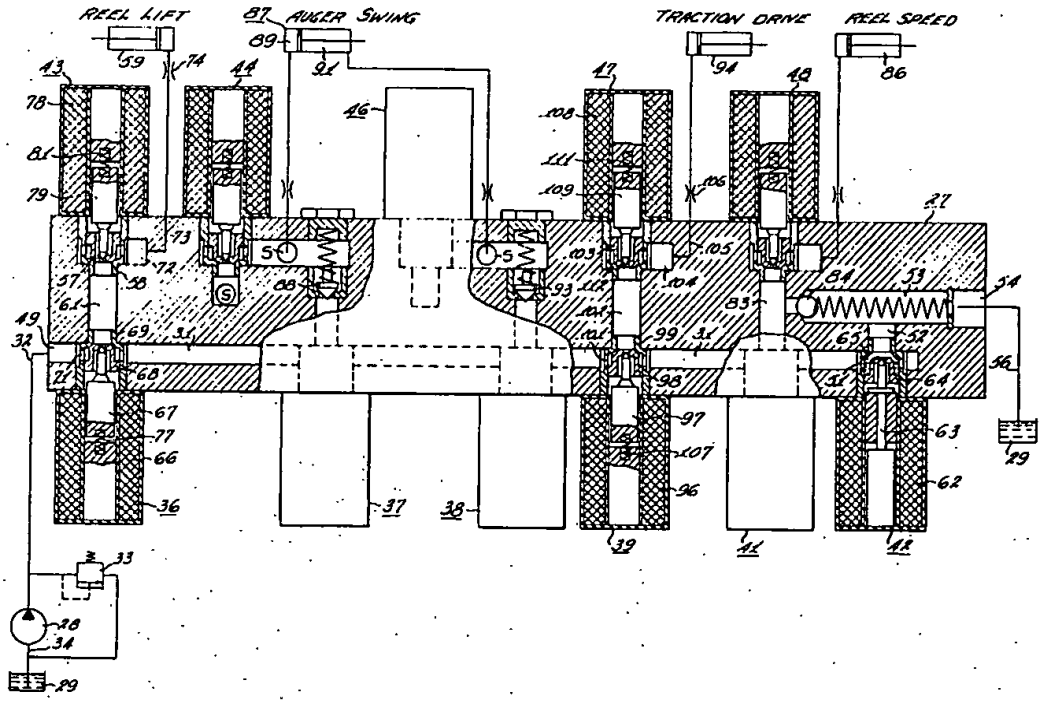
[57] **ABSTRACT**

A control valve consisting of two-way normally closed solenoid operated poppet valves and two-way normally open solenoid operated poppet valves. The normally closed solenoid operated valves are arranged to direct flow to and from a cylinder in the desired manner. For the control of each single acting cylinder, two normally closed solenoid operated valves are required, whereas, for a double acting cylinder, four normally closed solenoid operated and two check valves are needed. These sets of solenoid operated valves are incorporated in a single body or manifold to control the different functions on a combine such as reel height, reel speed, auger swing and tracton drive. The control valve also includes low flow circuit relief valve set at 2,000 psi and a 300 psi relief valve to satisfy maximum pressure conditions for reel speed operation. The valve is located near to a supply pump and the pump flow passes through the normally open two-way solenoid operated valve and back to sump to minimize pressure drop in neutral.

6 Claims, 4 Drawing Figures



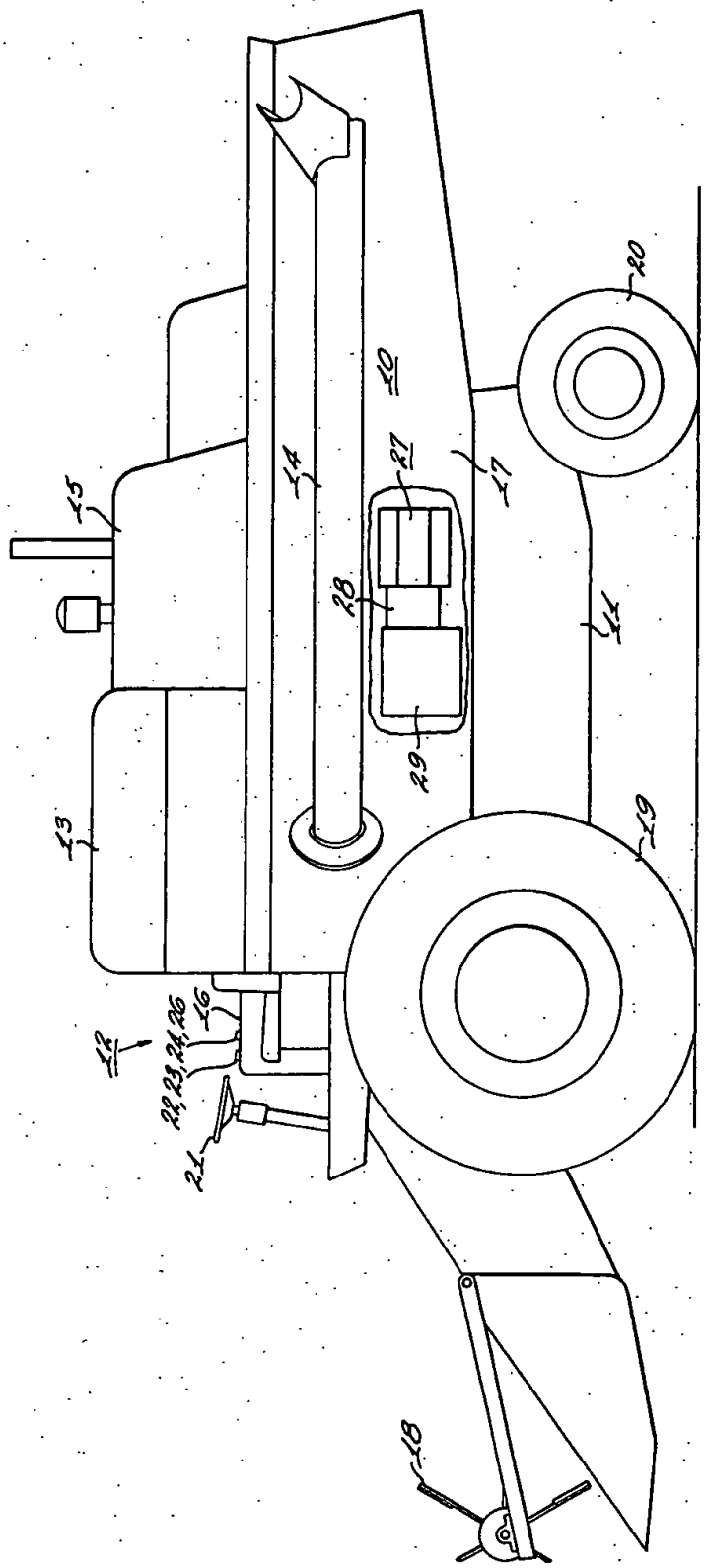


Fig. 1

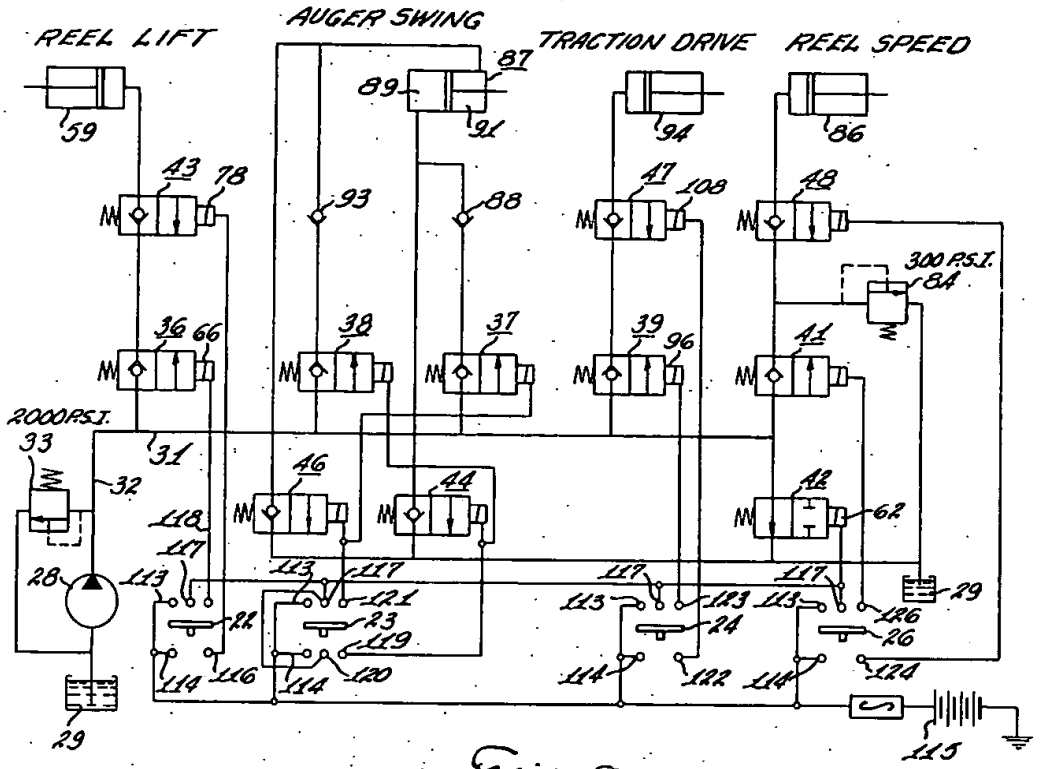


Fig. 2

TO OPERATE VALVE		ENERGIZE SOLENOIDS
REEL LIFT	RAISE	42 + 36
	LOWER	43
AUGER SWING	UP	42, 37 + 46
	BACK	42, 38 + 44
TRACTION DRIVE	FASTER	42 + 39
	SLOWER	47
REEL SPEED	RAISE	41 + 42
	LOWER	48

Fig. 4

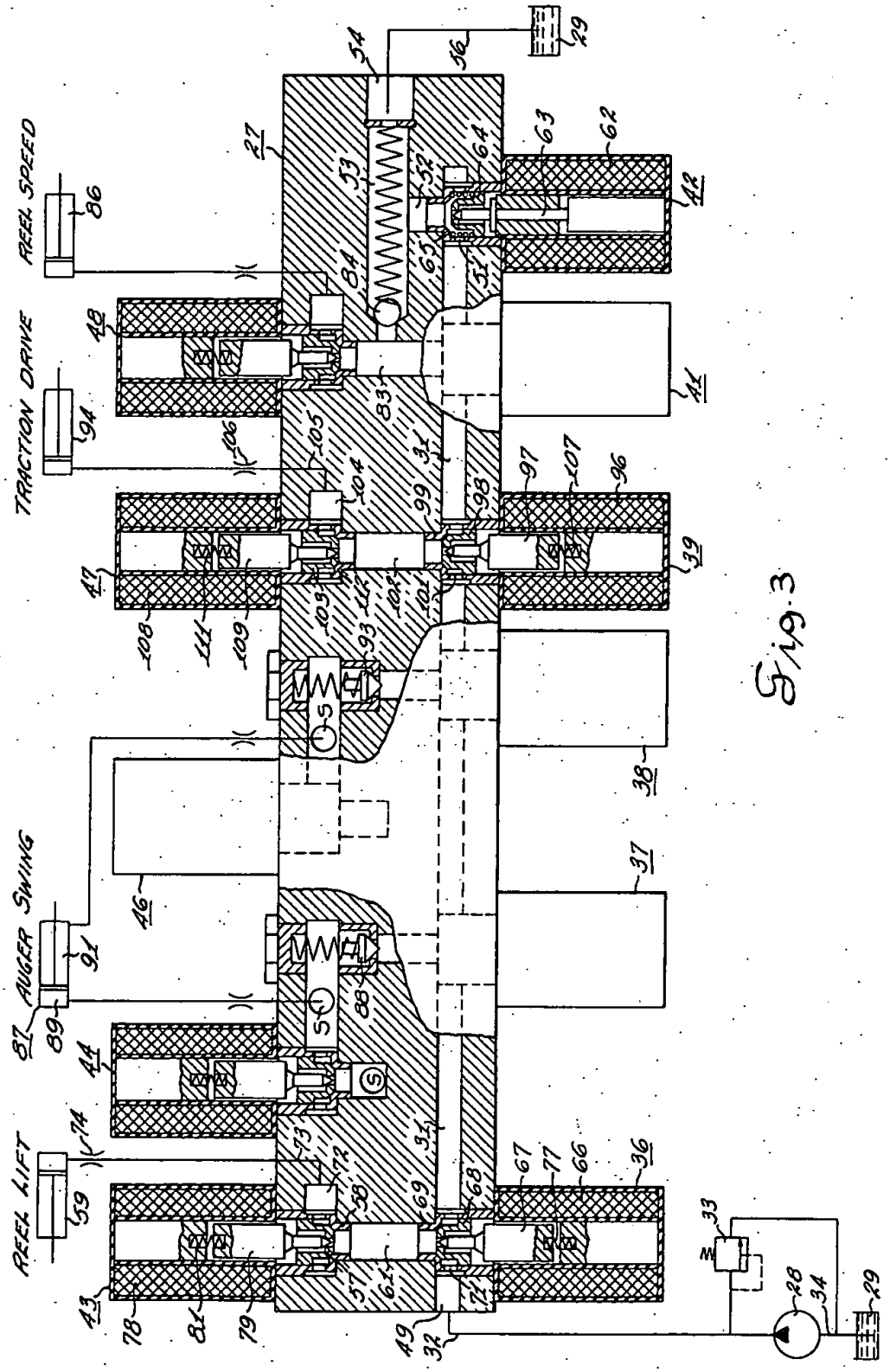


Fig. 3

ELECTROLIC CONTROL VALVE

An object of this invention is to provide an improved electrohydraulic control valve for controlling functions performed by single and double acting cylinders in an open center hydraulic system in a combine harvester.

Another object of this invention is to provide an inexpensive electrohydraulic control valve that will perform the funtions of three-way and four-way spool valves with lock out check valves on mobile equipment.

Another object of this invention is to provide two-way solenoid valves in an open center hydraulic circuit to perform functions previously performed by three and four-way spool valves with lock out check valves.

Another object of this invention is to provide a hydraulic system wherein solenoid valves provide one or more functions at lower pressure than system pressure.

A further object of this invention is to provide a hydraulic circuit having a hydraulic cylinder and utilizing solenoid valves and in which each solenoid valve works as a directional control valve to control direction of flow and as a check valve to a) isolate each function from the others in the circuit; and b) hold the hydraulic cylinder in activated position.

The present invention is particularly useful in combine harvesters for controlling a multiplicity of functions such a reel lift, reel speed, traction drive and auger swing.

Referring to the drawings:

FIG. 1 is a side elevation of a combine harvester embodying the invention;

FIG. 2 is a schematic view of the invention;

FIG. 3 is a section view through the valve body partially shown schematically; and

FIG. 4 is a summary of functions provided by various combinations of the solenoid valves.

Referring to FIG. 1, the invention is embodied in a self-propelled combine harvester 10 having a main frame 11 providing an operator station 12, a grain tank 13 provided with a swingable grain unloading auger 14, an internal combustion engine 15, an operator's console 16 and a harvesting and threshing and cleaning mechanism 17 including a reel 18 mounted on the forard end of combine 10. The foregoing are supported at the forward end of frame 11 on traction wheels 19 which are operatively connected to engine 15 by conventional means (not shown). The rearward end of the combine 10 is supported on dirigible wheels 20 operatively connected to steering wheel 21.

Mounted in the operator's console 16 is a group of electrical switches 22, 23, 24 and 26 (FIG. 2) which are positioned for easy manipuation by the operator when positioned at station 12 (FIG. 1).

A valve body or manifold 27 is positioned centrally on frame 11 in reasonably close relation to pump 28, sump 29 and the functions of the combine to be hydraulically controlled. Pump 28 is operatively connected to engine 15 by conventional means (not shown). Valve body 27 (FIG. 3) is provided with a main passage 31 connected at one end to conduit 32 to provide a passage between pump 28 and main passage 31. A conventional relief valve 33 is interposed between conduit 32 and conduit 34 leading from sump 29 to pump 28.

Solenoid valves 36, 37, 38, 39, 41 and 42 are mounted in valve body 27 in communication with main passage 31. solenoid valves 43, 44, 46, 47 and 48 are also mounted in valve body 27 in communication with main passage 31. Consider solenoid valves 36 and 43 which are two-way normally closed solenoid valves and two-way normally open solenoid valve 42 are arranged as shown in FIG. 3. For the present discussion consider that only these three valves are installed in the valve body 27 and the other valves are not present in FIG. 3.

Pump 28 is connected to the valve inlet port 49 of main passage 31. The pump flow with none of the switches 22–26 (FIG. 2) actuated is as follows: the flow (FIG. 3) goes through passages 31, 51, 52, 53, 54 and line 56 to the sump 29. Poppet 57 in solenoid valve 43 seats tight on the seat 58 and blocks the passage of flow from the cylinder 59 to cavity 61. Valve 43 serves as a lock valve to hold cylinder pressure constant and also serves as a directional control valve to direct flow from cylinder 59 to cavity 61.

To extend the movable element of reel lift cylinder 59, solenoid valves 42 and 36 are energized by pushing switch 22 upwardly. When coil 62 (FIG. 3) of solenoid valve 42 is energized, plunger 63 thereof moves and seats on poppet 64 which in turn moves together with plunger 63 and seats on valve seat 65 blocking flow between passages 51 and 52. The flow from pump 28 is now blocked from sump 29 and is available for any of the functions comprehended by the valves in valve body 27. The energization of coil 66 of valve 36 causes plunger 67 to move away from poppet 68 which moves away from seat 69 allowing hydraulic fluid to flow from passage 49 through passage 71 to cavity 61. When the pressure in cavity 61 exceeds the pressure in cylinder 59, such pressure lifts poppet 57 and the pump flow passes through passage 72, 73 and orifice 74 to cylinder 59. Orifice 74 controls the rate at which the piston of cylinder 59 extends or retracts. Excess flow, when orifice 74 is controlling the rate at which the piston of cylinder 59 extends, goes over the relief valve 33.

De-energizing coil 66 will remove holding force from plunger 67 and spring 77 will force plunger 67 to seat on poppet 68 which will position itself on seat 69 blocking passage 71 to passage 61. When coil 62 of solenoid valve 42 is deenergized, plunger 63 will move away from poppet 64 which moves away from seat 65 allowing the flow from pump 28 to go to sump 29. This puts valve 42 back into neutral position. In this neutral position reel lift cylinder 59 goes into hold position and is held by poppet 57 of solenoid valve 43 which acts as a lock valve.

To retract cylinder 59, solenoid valve coil 78 of solenoid valve 43 is energized by depressing switch 22 (FIG. 2) resulting in plunger 79 (FIG. 3) being pulled away from poppet 57 against spring 81. Poppet 57 moves away from seat 58 allowing hydraulic fluid from cylinder 59 to go to cavity 61. Pressure in the cavity 61 acts on the poppet 68 and moves it back. Oil flows from cavity 61 through passages 71, 31, 51, 52, 53 and 54 and line 56 back to sump 29. As soon as coil 78 of solenoid valve 43 is de-energized, spring 81 forces plunger 79 on the poppet 57 which in turn seats on seat 58 blocking flow from cylinder 59 to cavity 61. Poppet 68 also seats on seat 69 and valve 36 goes into neutral.

The steps described above illustrate complete operation of the reel lift section of the valve. The valve also has a traction drive section and a reel speed section which are identical to the reel lift operation and a repeat of describing such operation is not deemed necessary excepting that the reel speed function is carried on at 300 psi maximum pressure whereas the other functions, including the reel lift and traction drive, are at 2,000 psi. In the reel speed control operation, solenoid valves 41 and 48 are arranged in the same way as the previously described solenoid valves 36 and 43. A passage 83 is connected to a relief valve 84. Operation of this valve section is identical to the operation of the reel lift cylinder section in that when solenoids 42 and 41 are energized to extend the reel speed cylinder 86, hydraulic fluid flows from pump 28 through valve 41, cavity 83 and valve 48 to cylinder 86. Pressure in cavity 83 is sensed by relief valve 84 which regulates the pressure at 300 psi. However, this does not affect the system pressure which is regulated by a relief valve 33 at 2,000 psi. During operation of functions other than reel speed, solenoid valve 41 isolates cavity 83 from passage 31.

The auger swing section has a double acting cylinder 87 and operation of the auger swing is accomplished by solenoid valves 37, 44, 38 and 46. Operation of the solenoids is identical to that of solenoids 36 and 43 previously described.

Energizing solenoid valves 42, 37 and 46 will cause hydraulic fluid to flow through valve 37 and check valve 88 to the auger swing cylinder base end 89. Fluid from rod end 91 of the cylinder 87 will flow through valve 46 back to sump 29 and the cylinder 87 will extend. As soon as solenoid valves 42, 37 and 46 are de-energized, the movable element of cylinder 87 will go into hold position and be held by check valves 88 and 93 and solenoid valves 44 and 46.

When solenoid valves 42, 38 and 44 are energized, hydraulic fluid moves from pump 28 through valve 38 and check valve 93 to the auger swing cylinder rod end 91. Hydraulic fluid from the base end 89 goes to the sump 29 through solenoid valve 44 and cylinder 87 retracts. Cylinder 87 goes into hold position as soon as the solenoid valves are de-energized.

similar sections as described above, could be added to valve body 27 by adding additional sets of valves arranged in the same way as the auger swing section.

FIG. 3 shows the valve body 27 connected in any open center system. Pump 28 supplies hydraulic fluid into valve body 27 at inlet port 49 and such hydraulic fluid flows through passages 31, 51, 52, 53, 54 and line 56 back to sump 29. Whenever normally open valve 42 is energized, pump flow is blocked from returning to sump and pressure fluid becomes available to all sections of valve body 27. solenoid valves 36, 37, 38, 39 and 41 act as check valves and they isolate each section from the other. Any of the functions available in the valve housing 27 can be operated as previously described without affecting the rest of the functions.

In neutral, solenoid valves 43, 44, 46, 47 and 48 act as lock valves and hold the pressures in the respective cylinders. When these solenoid valves are energized, they act as directional control valves and direct flow from the pump to the cylinder or vice-versa. Thus, both the functions of lock or check valve and that of directional control valve are accomplished by the unique arrangement shown in FIG. 3. Solenoid valves 39 and 47 form the traction drive section and this section functions exactly as the reel lift section was described as functioning; namely: to extend traction drive cylinder, solenoid valves 39 and 42 are energized by raising switch 24 (FIG. 2). When coil 62 (FIG. 3) of solenoid valve 42 is energized, plunger 63 moves and seats on poppet 64 which in turn moves together with plunger 63 and seats on valve seat 65 closing the passage between 51 and 52. The flow of pump 28 is now blocked from the sump 29 and is available for any of the functions in the valve. When coil 96 of the solenoid valve 39 is energized, plunger 97 moves away from poppet 98 which moves away from seat 99 allowing hydraulic fluid to flow from passage 31 through passage 101 to cavity 102. When pressure in cavity 102 exceeds cylinder pressure, such pressure lifts poppet 103 and the hydraulic fluid passes through passages 104, 105 and orifice 106 to cylinder 94. Orifice 106 controls the rate at which cylinder 94 extends or retracts. Excess flow, when orifice 106 is controlling the rate at which cylinder 94 extends, goes over relief valve 33.

De-energizing coil 96 will remove the holding force from plunger 97 against spring 107 and spring 107 will force the plunger 97 to seat on poppet 98 which will seat on seat 99 blocking the passage from 101 to 102. When coil 62 of solenoid valve 42 is de-energized, plunger 63 will move away from poppet 64 which moves away from seat 65 allowing pump flow to go to sump 29. This puts the valve back into neutral position. In neutral, traction drive cylinder 94 goes into hold position and is held on poppet 103 of solenoid valve 47 which acts as a lock valve.

To retract the movable element of cylinder 94, solenoid coil 108 is energized which pulls plunger 109 away from poppet 103 against spring 111. Poppet 103 moves away from seat 112 allowing hydraulic fluid from cylinder 94 to go to cavity 102. Pressure in cavity 102 acts on poppet 98 and moves it back. Hydraulic fluid flows from cavity 102 through passages 101, 31, 51, 52, 53, 54 and line 56 back to sump 29. As soon as coil 108 of solenoid valve 47 is de-energized, spring 111 forces plunger 109 on poppet 103 which in turn seats on seat 112 blocking flow from cylinder 94 to cavity 102. Poppet 98 also seats on seat 99 and valve 39 goes into neutral.

Referring to FIG. 2, each of the switches 22, 23, 24 and 26 are shown to be of a double throw type. Each switch is provided with an upper connection 113 and a lower connection 114 leading to electrical power source 115 on combine 10. Switch 22 is provided with a lower lead 116 connected to the coil 78 of solenoid valve 43 so that by depressing switch 22 coil 78 is energized. Switches 22, 23, 24 and 26 are also provided with an upper contact 117 which is connected to the coil 62 of solenoid valve 42. Switch 22 is also provided with an upper lead 118 connected to the coil 66 of solenoid valve 36 so that by moving switch 22 upwardly power is supplied to lines 117 and 118 for energizing solenoids of values 36 and 42.

Switch 23 is provided with a lower contact 119 connected to the coil of solenoid value 44 and the coil of solenoid value 38 and switch 23 is also provided a lower contact 120 connected to contact 117 so that when switch 23 is depressed the solenoids of values 42, 44 and 38 are actuated for connecting the piston head end of cylinder 87 with line 31 and a souce of hydraulic fluid and the rod end of cylinder 87 is connected up

with sump 29, respectively. Switch 23 is also provided with an upper contact 121 connected to the coils of solenoid valves 37 and 46 so that when switch 23 is raised valves 37, 42 and 46 are actuated, the piston head end of cylinder 87 is connected to sump 29 and the rod end is connected to line 31 for receiving hydraulic fluid from pump 28.

Switch 24 is provided with lower contact 122 connected to the coil of solenoid valve 47 so that when switch 24 is depressed the solenoid of valve 47 is energized connecting cylinder 94 with sump 29 through solenoid valve 39. Switch 24 is also provided with an upper contact 123 so that when switch 24 is raised the solenoids of valves 42 and 39 are energized and hydraulic fluid flows from pump 28 to cylinder 94 extending the piston of same.

Switch 26 is provided with lower contact 124 connected to the coil of solenoid valve 48 so that when switch 26 is depressed solenoid valve 48 is acutated to connect cylinder 86 with sump 29 through solenoid valve 41. Switch 26 is also provided with an upper contact 126 so that when switch 26 is raised the solenoids of values 42 and 41 are energized and hydraulic fluid flows from pump 28 to cylinder 86 extending the piston of same.

I claim:

1. In combination in self-propelled mobile equipment having a console positioned at an operator's station, said equipment being provided with an open center hydraulic system including a pump, manifold, cylinders and sump for hydraulically controlling mechanisms on said equipment, the improvement comprising electrical means including switches positioned in said console for controlling said cylinders, said cylinders being connected to said mechanisms for three position control in extending a movable element of said cylinders, in holding the movable element of said cylinders or in retracting the movable element of said cylinders; said electrical means including sets of single and double acting solenoid valves positioned in said manifold and being connected to said switches and to said cylinders for providing said three position control; and a normally open solenoid valve is operatively interposed in said manifold between said pump and sump for permitting hydraulic fluid provided by said pump to pass through said manifold and return to said sump, and first and second ordinarily closed solenoid valves are positioned in said manifold between said pump and a selected hydraulic cylinder, said first valve functioning as a check valve and said second valve functioning as a flow control valve so that upon closing of selected switches on said console said normally open solenoid valve will be closed permitting buildup of hydraulic pressure in said manifold and with an opening of said first solenoid valve hydraulic fluid is supplied through said second solenoid valve for extending a selected cylinder.

2. The combination recited in claim 1 and wherein said first ordinarily closed solenoid valve is a check valve and said second solenoid valve is a flow control valve so that when said first valve is actuated to closed position hydraulic pressure will increase in said manifold until said flow control valve is overcome resulting in extension of the movable element of said selected cylinder.

3. The combination recited in claim 2 and wherein a plurality of lines are hydraulically connected between said manifold and said selected cylinder, first and second ordinarily closed solenoid valves are interposed in each of said lines between said manifold and said hydraulic cylinder, said first ordinarily closed solenoid valves being located adjacent to said manifold and being check valves, and said second ordinarily closed valves being located remote to said manifold and being flow control valves.

4. The combination recited in claim 2 and wherein one of said hydraulic cylinders is designed for operation at hydraulic pressure less than the normal pressure of said manifold, a relief valve positioned in a line between said solenoid valves and being set to reduce the pressure in said line to the lesser amount required by said cylinder connected to said one of said lines.

5. The combination recited in claim 3 and wherein two of said lines are connected to opposite ends of a two-way hydraulic cylinder, and an additional flow control valve is interposed in said two lines between said second solenoid valves and said two-way hydraulic cylinder.

6. The combination recited in claim 1 and wherein a pair of lines are hydraulically connected between said manifold and opposite ends of a two-way hydraulic cylinder, a first normally closed solenoid valve connected in each of said lines adjacent to said manifold and functioning as check valves, flow control valves positioned in said lines between said cylinder and said first solenoid valves, a pair of lines hydraulically connected to each of said lines between said cylinder and said flow control valves and each of said pair including a normally closed solenoid check valve interposed between said flow control valves and sump for permitting two-way operation of the movable element of said cylinder.

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